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INTEGRATED SERVICES DIGITAL NETWORK

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CONTENTS

INTRODUCTION

Why ISDN?

The public telephone system exists in two main categories:

- ***Public Switched Telephone Network (PSTN)*** simple but efficient, used by all of British Telecom's telephony and dial-up data service customers.
- ***Packet SwitchStream (PSS)*** a sophisticated public switched network, for data customers only.

Some of British Telecom's customers have also created extensive private networks, utilising leased circuits, which they use for speech and data. Such private networks include KiloStream and MegaStream.

More efficient, more economical and faster communication has become a priority for modern business. To meet this demand, it is British Telecom's policy to offer a single service combining the qualities of all the existing networks, as well as serving the needs of the future.

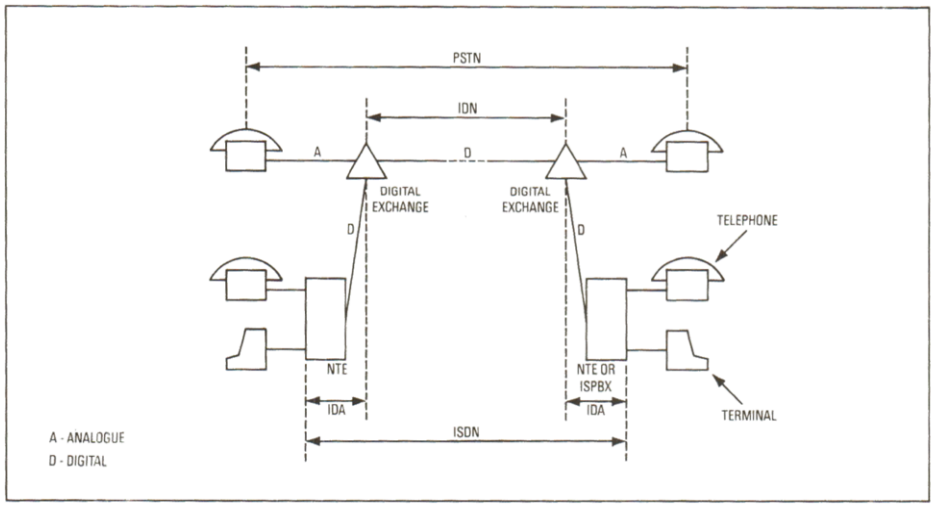


Figure 1
Relationship between the PSTN, IDN, ISDN and IDA

By introducing digital exchanges (System X and AXE 10), British Telecom is creating an integrated digital network (IDN), and is utilising this network to offer a new multifunction service to its customers. This service is known as the *integrated services digital network* (ISDN). The ISDN uses all the elements of modern digital communications; that is, digital switching, digital transmission and powerful computer intelligence, but adds one more key element, as shown in Figure 1—digital transmission from the digital local exchange to the customer. This key element is known as *integrated digital access* (IDA).

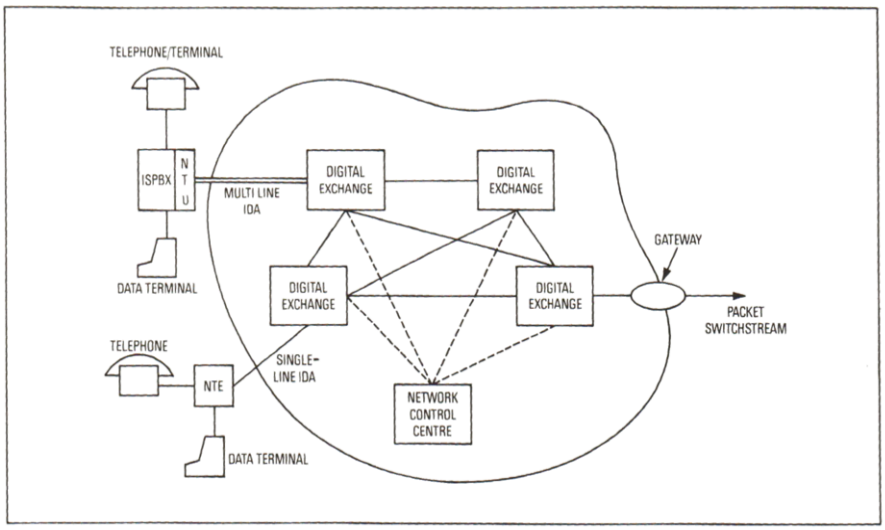
The ISDN is a national service which will evolve from the existing PSTN. British Telecom is marketing its pilot ISDN service as 'IDA'.

ISDN OVERVIEW

General

From the digital exchanges, local digital access circuits fan out to customers' premises, where they terminate on a network terminating equipment (NTE) or a network terminating unit (NTU). At key points in the network, links, known as *gateways*, are provided to other networks (see Figure 2).

Figure 2
British Telecom's ISDN service



In addition to the local networks, international gateways to other ISDNs are also planned (Italy and Germany are currently developing similar systems) making the ISDN a 'complete' multifunction service.

Remote Access

Although all digital local exchanges have ISDN capability, the provisioning of IDA lines necessitates specialist IDA equipment (known as *IDA modules*) to be provided. ISDN service, therefore, can be provided only by those exchanges that have been equipped with this special IDA equipment.

To provide ISDN service to customers on local exchanges which have not been so equipped, a method of providing remote access has been developed using equipment known as a *remote IDA multiplexer*.

Customer Benefits

ISDN customers are given the option of high-speed high-quality data and text communication, at higher speeds than hitherto possible over the PSTN. They are able to support, over the same network, services such as:

- telephony,
- circuit-switched synchronous and asynchronous data services,
- digital private circuits, that is, KiloStream,
- Packet SwitchStream (PSS),

to allow such applications as the following:

TELEPHONY

By using an IDA digital telphone (IDAphone) with a Network Terminating Equipment No. 4 (NTE4), normal PSTN telephony calls can be made. These have the advantages of improved reliability and performance because of the digital technology.

CIRCUIT-SWITCHED DATA SERVICE

Customers have circuit-switched data service for both synchronous and asynchronous data without the additional costs of having to provide modems.

Facsimile IDA will support digital facsimile at rates up to 64 kbit/s based on CCITT group 4 or enhanced group 3 machines.

Teletex Services Any terminal, for example, a word processor, connecting via IDA with Teletex (a high-speed electronic service for communicating text) will be able to communicate with any other terminal anywhere in the world.

Datel Services The NTE4 (when used with a suitably profiled external interface adaptor) can interwork with most Datel users' equipment at specified rates up to the bearer rate of the channel used.

Photo Videotex IDA will permit access to remote information databases in a similar manner to Prestel, but the network capabilities will permit the information to be enhanced by high-resolution graphics and pictures. Potential users include wholesale mail order companies, estate agents and travel agents.

Slow-Scan Television This service provides good-quality television pictures which are transmitted by taking a still picture every 4 seconds. This can be used for security surveillance, or audiovisual conferencing.

PRIVATE CIRCUIT DATA SERVICES

Where traffic volumes demand, there is still a need to provide dedicated permanent connections. For this, British Telecom allows one channel of a single-line IDA to be used as the local end of a private high-speed circuit. An example of this application would be a broker using it for permanent access to the Stock Exchange.

ACCESS TO PACKET SWITCHSTREAM (PSS)

Customers are given facilities for accessing the PSS network by using synchronous packet terminals. One of the single-line IDA channels may be dedicated to PSS use.

INTEGRATED SERVICES PBX (ISPBX)

The facilities that a digital PABX offers will depend upon the manufacturer's specifications. In its simplest form, the PBX will have enhanced telephony facilities. The more advanced PBXs will provide some or all extension users with capabilities similar to that provided by single-line IDA.

SUPPLEMENTARY SERVICES

Although System X telephony supplementary services have not initially been offered to ISDN customers, as the system develops, those who have the telephony option will be offered these services.

In addition to the telephony supplementary services, ISDN customers have the advantage of being offered two additional data-only supplementary services:

- ***Closed User Group (CUG)*** A CUG is a group of ISDN users who are able to intercommunicate to the exclusion of other ISDN users who are not members of the group. Members of a CUG can be geographically anywhere on the ISDN and there is no limit to the number who can belong to a given group.
- ***Calling and Called Line Identification*** This enables the calling customers' identity, in the form of a national number referred to as the *originating line identity* (OLI), to be sent to the called customer, and the identity of the called customer, referred to as the *terminating line identity* (TLI), to be returned to the calling customer.

IDA, British Telecom's pilot ISDN service, is now considered in more detail.

INTEGRATED DIGITAL ACCESS

Two forms of integrated digital access (IDA) have been developed:

- single-line IDA, and
- multi-line IDA.

Single-Line IDA

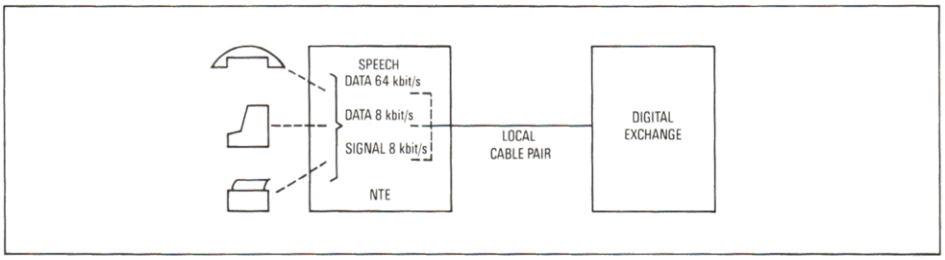
With single-line IDA, a two-wire line is provided to the customer's premises where it terminates on a network terminating equipment (NTE), see Figure 3. The ability of single-line IDA to use existing local telephone wires means that a customer, already on the PSTN, will not require new line plant between the digital exchange and the customer's premises.

This single-pair line carries two traffic channels each with a different directory number:

- one operating at 64 kbit/s to carry speech or data, referred to as the *B channel*; and
- the other operating at 8 kbit/s for data services, referred to as the *B′ channel*.

There is also a third channel, operating at 8 kbit/s, known as the *D channel*. This channel is used for call set up and supervisory signalling and is not allocated a directory number.

Figure 3
Single-line IDA



The sum bit rate of all three channels is 80 kbit/s. The system is therefore generally referred to as operating at 80 kbit/s.

B	64 kbit/s main channel telephony/data
B′	8 kibt/s data only
D	8 kbit/s signalling
	80 kbit/s

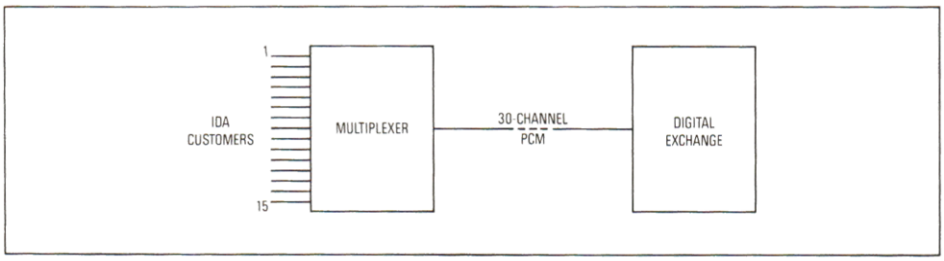
It should be noted however, that the actual line rate is higher than 80 kbit/s and depends upon the line transmission technique used.

Single-Line IDA via Remote Multiplexer

Customers who are still served by analogue exchange equipment can be provided with ISDN service by means of an IDA multiplexer, known as a *remote multiplexer* (RMUX).

This multiplexer provides single-line IDA connections for up to 15 customers, the multiplexer being connected to a digital local exchange over a 2 Mbit/s (30-channel) digital path (see Figure 4).

Figure 4
Access to ISDN via remote multiplexer



It should be noted that this is not a standard 30-channel pulse-code modulation (PCM) multiplexer, but a special IDA multiplexer, and the two should not be confused.

Each customer is allocated two of the 30 PCM channels between the multiplexer and the local digital exchange: one for the 64 kbit/s telephony/data channel and one for the 8 kbit/s data-only channel. The customer's other 8 kbit/s signalling channel is carried by a common signalling channel within the 30-channel PCM system, known as *time-slot 16* (TS16).

At the local digital exchange, special equipment is provided to receive the 2 Mbit/s signals. This equipment is known as a *2 Mbit/s IDA line module*.

Single-Line IDA via KiloStream

A further means of access can be provided via the KiloStream network. By using two 64 kbit/s bearer circuits (the term used to describe traffic carrying channels on KiloStream) and appropriate interworking equipment, IDA service can be given to a customer who does not have access to a digital exchange, or a remote multiplexing site. This facility is seen as an exceptional expedient, and its use is expected to be very limited.

Multi-Line IDA

Multi-line IDA provides a customer with a full 30-channel PCM system from his/her premises to the local digital exchange. Each of the thirty 64 kbit/s channels has its own identity within the numbering scheme of the local exchange, see (Figure 5).

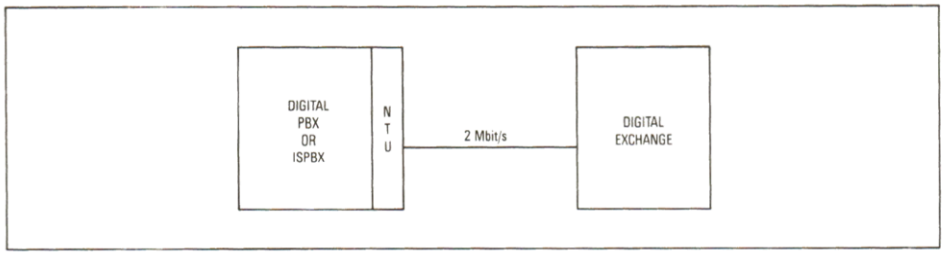


Figure 5
Multi-line IDA

At the customer's premises, the 30-channel PCM (2 Mbit/s) link terminates on a network terminating unit (NTU), where it is connected to the customer's equipment. This will usually be a digital PBX or one of the integrated services private branch exchanges (ISPBXs) currently being developed. At the local digital exchange, the 30-channel PCM link terminates on a 2 Mbit/s IDA line module.

Figure 6 illustrates the various methods of providing access to British Telecom's pilot IDA.

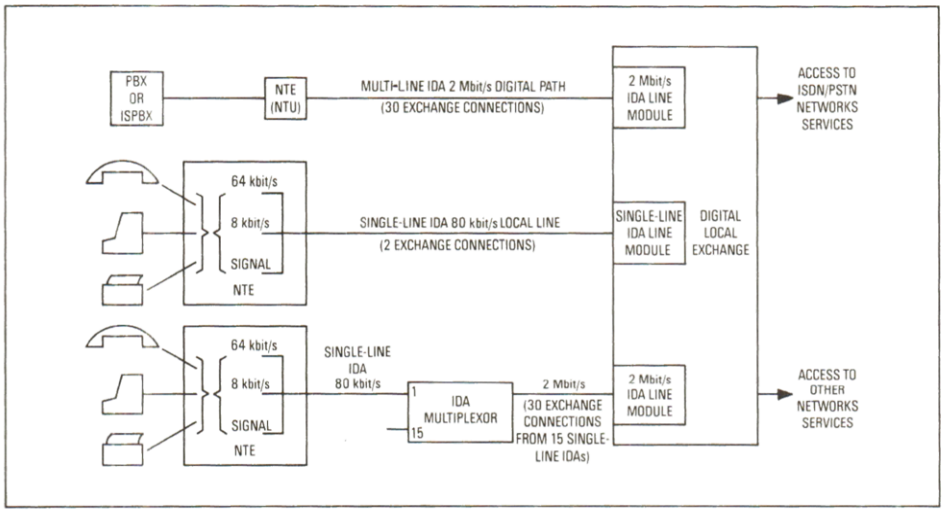


Figure 6
Methods of providing IDA pilot

IDA LINE TRANSMISSION METHODS

Local Line Transmission

The existing local cable network connecting a customer to the local digital exchange allows for a maximum attenuation loss of 15 dB (at 1600 Hz) between the customer and the local exchange. This network was originally designed to carry analogue signals with a bandwidth of 4 kHz. It is possible, however, to use it to carry the wider single-line IDA bandwidth by using transmission techniques known as *burst mode* and *adaptive echo-cancelling*.

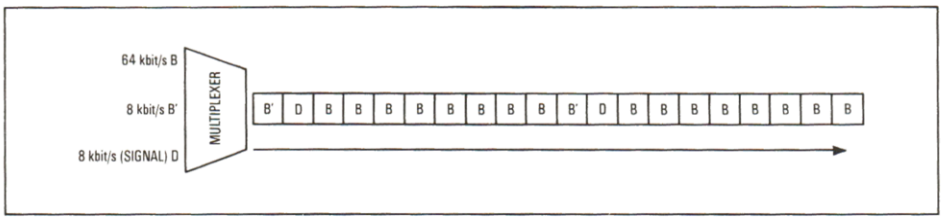
Note: At an information rate of 80 kbit/s, the bandwith requirement is in the order of 100–256 kHz, depending upon the transmission system used.

As a consequence of using either of the above techniques, the signals are subjected to a much greater attenuation than the telephony signal and, therefore, for its early ISDN service, British Telecom has limited the pilot single-line IDA operating line loss to 28 dB at 256 kHz for burst mode (with a maximum operating distance of approximately 2·5 km) and 40 dB at 100 kHz for echo cancelling (with a maximum operating distance of approximately 3·7 km).

Future echo-cancelling systems operating at 144 kbit/s and above, by utilising advanced integrated circuit techniques, will allow this operating distance to be increased considerably.

In addition to the tranmission technique used, the basic performance of single-line IDA is further enhanced by the use of the line code WAL2. This simple line code allows the signal to be transmitted over the unloaded local cable without introducing excessive pulse distortion to adjacent circuits.

Figure 7
User data and signalling information in multiplexed format



Within the customer's NTE, a channel multiplex processor is responsible for multiplexing bits of data from each of the three channels and forming them into 20 bit blocks as shown in Figure 7. These are then passed to an interface module for line coding before being transmitted to line via the line transmission termination board (LTT).

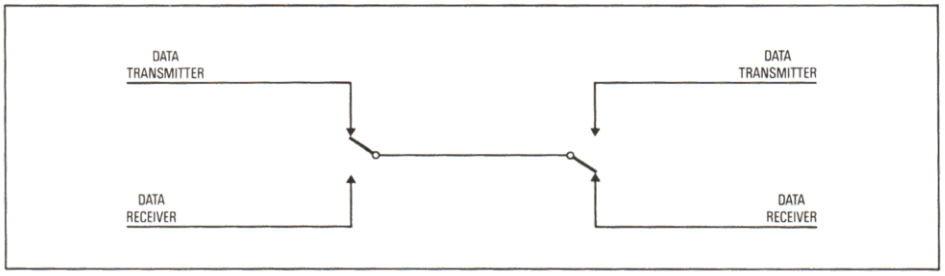
Burst-Mode Transmission Technique

Normally, IDA customers who are within 2·5 km of an ISDN exchange or an IDA remote multiplexer site use the burst-mode line transmission system. This allows 22 bits (20 information bits and two line code marker bits) to be transmitted to line in a burst in each direction every 250 μs.

Located at each end of the line is a transmitter and receiver. They are connected to line for the time period to allow one block of data to be transmitted and received.

Once the block of data has been transmitted, the line is switched to allow transmission in the opposite direction, as shown in Figure 8.

Figure 8
Principle of burst-mode working



The signals transmitted to line by the current burst-mode system have most of their energy at 256 kHz and this allows a permissible line loss of 28 dB at this frequency. This gives an operating distance of up to 2·5 km over cable consisting of 0·4 mm copper conductors. This limit, however, is considerably reduced if used on local cable comprising aluminium conductors.

Adaptive Echo-Cancelling Transmission Technique

To extend the single-line IDA transmission limit, British Telecom uses a method based on the adaptive echo-cancelling tranmission technique by using equipment known as the *WB 1900*.

Adaptive echo-cancelling allows both the data transmitter and the data receiver to be connected to line simultaneously and, therefore, by using this method, it is possible to transmit and receive at the same time; that is, a full duplex system. This is different from the burst-mode method, which only appears to give full duplex. (The burst-mode method transmits in one direction and then in the other direction so fast, the overall effect appears to be full duplex.)

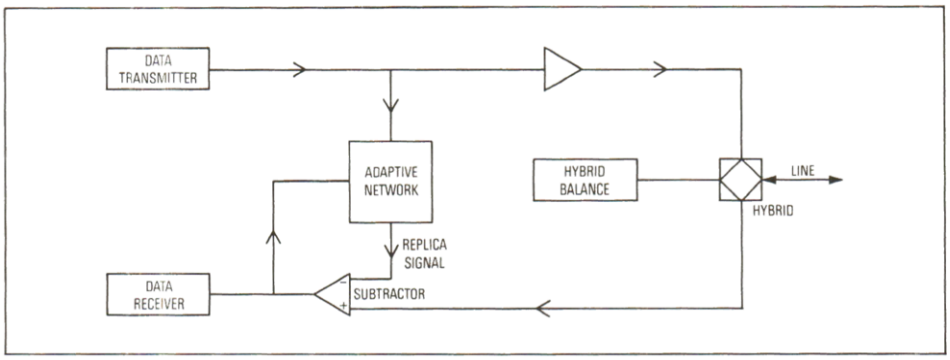


Figure 9
Principle of echo cancelling

Since the echo-cancelling transmission system used by the digital circuit of the WB 1900 is very complex, the technique is best illustrated by considering the analogue echo-cancelling circuit shown in Figure 9. The principle used is to cancel any echo that may be present at the receive side of the hybrid. The adaptive network creates a replica signal of the echo by comparing the transmit and receive signals. This replica signal (that is, the output of the adaptive network) is then subtracted from the received signal, and thus the echo component is removed from the wanted signal.

The signals transmitted to line by the WB1900 have most of their energy at 100 kHz. This gives a maximum permissible line loss of around 37 dB when used over cable comprising 0·4 mm copper conductors. (This limiting factor gives the maximum operating distance of approximately 3·7 km.).

IDA SIGNALLING

Signalling Methods

With the introduction of ISDN, it was necessary to provide a signalling system capable of coping with the speed and repertoire appropriate to the full range of services and facilities available on ISDN. No CCITT Recommendations on customer access signalling systems were available at the time British Telecom was designing its ISDN, so a totally new digital signalling system was developed.

The signalling system, known as *digital access signalling system* (DASS), is used between the customer and the digital local exchange.

Two versions have been developed:

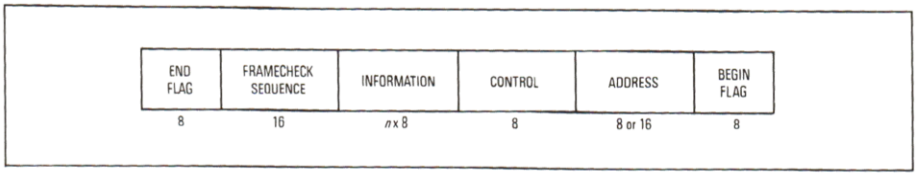
- DASS1, for single-line digital access (direct or via remote multiplexers, RMUX), and
- DASS2, for ISPBXs and I-series multiplexers (IMUX) (see later).

DASS1

DASS1 is a message-based common-channel signalling system using variable length frames based on the international high level data link control (HDLC) standard.

It formats the message as shown in Figure 10 and is used on the dedicated 8 kbit/s signalling channel (D channel) of a single-line IDA customer, working either directly or via a remote multiplexer, to carry signalling and supervisory signals.

Figure 10
DASS1 format



The information contained in each section is as follows:

Address	Identifying channel.
Control	Identifying the type of information to follow (that is, information, reset, acknowledgement).
Information	Message, a maximum of 32 × 8 bit words.
Check	Frame sequence check for error detection.

DASS1 is also used to perform another important function, one that is a feature of IDA: it continually monitors the local line.

A design feature of the digital network is its ability, within the trunk network, to continually monitor continuity between exchanges. (This provides for greater reliability by identifying a fault condition the instant it occurs). Because of the structure of the local line network and the analogue nature of the connection between a customer's direct exchange line and the digital exchange, continual monitoring is not provided over the local network. Routine checks are confined to monitoring the connection for physical malfunction; for example, battery contact, earth contact, short circuit etc. This means that a disconnection in the local line could go undetected until a customer reports the line out of order (that is, the responsibility lies with the customers to check they have dial tone).

By utilising DASS 1, the digital local exchange can continually monitor the IDA customer's connection. If a disconnection is found, an alarm is given in the exchange.

DASS 2

The development of digital PABXs and the use of digital leased lines to form digital private networks led to the need for an inter-PABX signalling system. British Telecom and a number of UK PABX manufacturers collaborated to produce a signalling system called *digital private network signalling system* (DPNSS).

It became apparant that the DASS system would need to align with the DPNSS system to enable both inter-PABX links on private circuits and PABX-to-network signalling.

An enhanced version of DASS1, known as *DASS2*, has evolved incorporating changes arising from the above need; that is,

- to give ISDN access to PBXs; and
- to incorporate additional supplementary facilities such as network address extension, user-to-user signalling and call charge indication.

DASS2 serves multi-line IDA customers requiring multiple access to ISDN and is used on the dedicated 64 kbit/s signalling channels (time-slot 16) of the 2 Mbit/s digital link connecting the customer to the digital local exchange.

It will also be provided on AXE 10 digital local exchanges and will be utilised to support the next generation of IDA multiplexers (the I-series multiplexer, known as the *IMUX*) for multiplexer-to-exchange signalling.

DASS2 is based on the international HDLC standard and has a similar format to DASS1, but varies in the number of bits allocated to the sections of the message.

Not all the facilities supported by DASS 2 will be available from the outset of ISDN; for example, the signalling facility required to give ISPBX extensions access to the System X supplementary services and the proposed facility for maintenance messages to be generated by the ISPBX. As ISDN evolves, however, all forms of access will be able to obtain a comprehensive set of services supported by DASS2.

NETWORK TERMINATING EQUIPMENT

Introduction

All the equipment currently available for use on ISDN benefits from modern technology to give exceptional reliability and performance combined with the flexibility, greater accuracy and speed of digital transmission.

Customers who require single-line access can rent from British Telecom an IDA complete with Network Terminating Equipment No. 4 (NTE4), which provides two X.21 user channels, one at 64 kbit/s and one at 8 kbit/s.

In addition to this standard equipment, customers can also purchase an optional external interface adaptor and/or an IDA digital telephone. This optional equipment, so long as it is approved for connection to the network, does not have to be supplied by British Telecom.

It should be noted that the NTE4 cannot be used to support telephone service unless associated with an IDA digital telephone and a stand-by battery unit. The stand-by battery is provided as part of the network termination in compliance with British Telecom's operating licence.

NTE4

The main function of a network terminating equipment is to provide the interface between the customer's equipment and the ISDN. It acts as the terminating point for the two-wire line between the local digital exchange and customer. In Datel terminology, it is referred to as the *data circuit-terminating equipment* (DCE).

In addition to multiplexing the two user channels and the signalling channel onto a common data path (the two-wire local line), the NTE4 also provides data rate adaption between the customer's data terminal equipment and the network. This allows each IDA channel to transport, at the bearer rate, data which is received from the customer's terminal at a slower rate.

The design of the NTE4 incorporates advanced rate adaption schemes, which enable it to interwork with the forthcoming generation of ISPBXs.

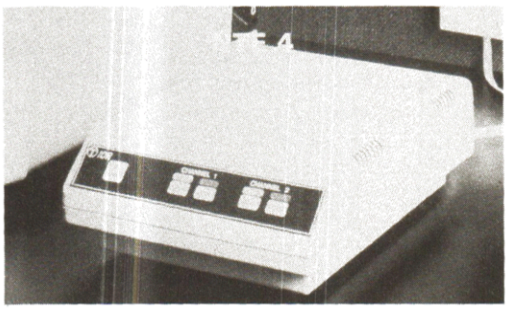


Figure 11—General view of NTE4

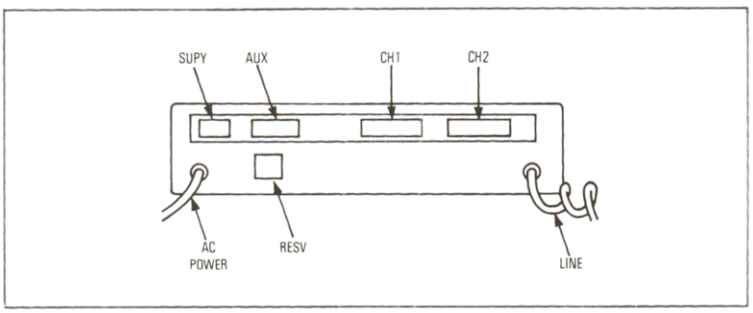


Figure 12—Rear view of NTE4

Description of the NTE4

The NTE4 is similar in appearance to a small modem, and comes in a 265 mm × 78 mm biege case weighing 1·6 kg. It is supplied to IDA customers complete with line cord and a mains lead terminated in a moulded mains plug.

The NTE4 can be used as a table-top item, or mounted vertically on a wall. At the rear, as shown in Figure 12, it offers two data ports (labelled CH1 and CH2), with additional ports (labelled SUPY and AUX) for use when facility programming. It has no keypad, or display and supports X.21 data terminals. In order to facilitate interworking to peripheral terminals that are not designed to the CCITT X.21 Recommendation, for example, V.24/X.21*bis* terminals, a range of external adaptor modules are available to connect onto the data ports.

With the NTE4, customers can transmit and receive data at rates of up to 64 kbit/s by using the port labelled CH1 and transmit and receive data at rates up to 8 kbit/s using the port labelled CH2. Both data ports are designed to CCITT Recommendation X.21.

Facility Programming the NTE4

Before the NTE4 can be used successfully, it needs to be programmed with setting up information. This is known as *profiling*.

Profiling involves specifying the service type (that is, data, slow-scan TV, Teletex etc.), the call type (X.21 offers a choice of private, switched or leased), the destination number and the data transmission speed to be used by the NTE4.

This information is very important because a code that represents a combination of the service type and channel speed profiled into the NTE4 (known as the *service indicator code* (SIC)), is used by the system/network to set up the connection when the ISDN customer initiates a call.

In addition to the above parameters, because each data channel is able to handle either outgoing or incoming calls, a call mode option is offered which allows the user to define the condition under which data will be accepted into the NTE4.

Customers can profile their NTE4 by using their own supervisory terminal (that is, an ASCII keyboard/display terminal or an external adaptor known as the *X21bis adaptor* (see Figure 13) offered by British Telecom and specially designed for use with the NTE4 which can additionally be used in a supervisory role), by connecting it to the port labelled 'AUX' at the rear of the NTE4 (see Figure 12).

Figure 13—British Telecom X.21*bis* adaptor

Figure 14—British Telecom IDAphone

Making a Data Call

When profiled, the NTE4 is simple to use; customers simply connect their terminal equipment (DTE) to the appropriate data port at the rear of the NTE4.

X.21 circuit-switched calls can be made directly from the DTE in accordance with the manufacturer's instructions. The call is made to a directory number selected by the DTE. X.21 direct calls can be made to directory numbers profiled in the NTE4.

Calls from customer X.21 leased-line DTEs can be made by using either the membrane button label CALL on the front of the NTE4 associated with the port used, or customers may use their supervisory terminal by requesting a menu driven CALL SETUP sequence. The call is automatically dialled and the connection made. Data can then be sent. Indication that the call has been established is given by a light-emitting diode (LED) indicator in the appropriate CALL button.

It should be noted that leased-line calls may be set up only via the NTE4 front panel or supervisory terminal if the selected channel has already been profiled to handle leased-line calls.

Receiving a Data Call

Incoming calls may be routed to either channel depending on the directory number called. When the NTE4 detects an incoming call on one of the data channels, providing the service indicator code (SIC) is compatible, the front panel CALL indicator for that channel lights up. If the customer has a supervisory terminal connected to the AUX port, it displays the call status information; this includes the originating line identity (OLI) directory number and the closed user group identity (CUG).

If the service indicator code (SIC) is not compatible or the customer's terminal equipment is not ready, the incoming call is rejected and the message 'DTE uncontrolled not ready' sent back to the caller.

Telephone Calls

British Telecom's IDAphone is radically different from any previous British Telecom telephone equipment (see Figure 14) and can be used in conjunction with the NTE4 to provide voice communication. It also incorporates a V.24 data port that enables standard data terminal equipment to be connected, via the IDAphone to the ISDN. British Telecom's IDAphone has been specifically designed for use with the channel 1 port of the NTE4 and is connected via a 15-way cable, which comes supplied with the IDAphone.

Before a customer can use the IDAphone facility, his/her NTE4 requires to be enabled for telephony, and channel 1 appropriately profiled for telephony operation.

Once this has been done, telephone calls can be made in accordance with the instructions supplied with the IDAphone.

FUTURE DEVELOPMENTS

I-Series Recommendations

British Telecom is a market leader in providing an integrated services digital network. Its UK pilot IDA was nearing completion when international discussions on ISDN standards had only just started within the CCITT.

The overall guidelines and relevant Recommendations on ISDN now emerging from those discussions are contained in a series of Recommendations known as the *I-series*.

Although the full range of I-series Recommendations has not been fully agreed (there are currently no Recommendations on ISDN maintenance principles or internetwork interfaces), those that have been agreed indicate that the future standard for single-line IDA will be based upon 144 kbit/s, to allow two traffic channels (B + B) each operating at 64 kbit/s and a signalling channel (D) operating at 16 kbit/s (Recommendation I.412 describes the access capabilities for ISDN).

The I-series Recommendations also define a basic access interface (I.412) which will eventually replace the X.21 Recommendation used on British Telecom's IDA. Use of X.21 and X.21*bis* data terminal equipment (DTE), however, will continue to be supported, as will the use of other terminals operating to existing interface standards by the use of terminal adaptors.

The new Recommendations also include a D-channel signalling protocol. It is unlikely, however, that these Recommendations will be capable of supporting multi-line IDA for a considerable period owing to the additional specifications required in the Recommendations. British Telecom will continue to offer DASS2.

144 kbit/s System (IMUX)

Adoption of the CCITT I-series interface is the next phase of ISDN in the British Telecom network. The introduction of multiplexer equipment known as the 'IMUX' will allow British Telecom to offer customers a 144 kbit/s echo-cancelling transmission system over the local cable pair.

Specifications for the IMUX and a contract for the development and supply of equipment was awarded to STC in 1986. Customer provision is anticipated to commence in late-1988.

Up to 15 single-line IDA terminations will be connected to an IMUX (co-located in the digital exchange) which, in turn, is directly connected to the digital local exchange via a 2 Mbit/s link. This 2 Mbit/s link will use the DASS2 signalling system which is currently used for the pilot multiline IDA. In British Telecom's pilot ISDN service, a direct exchange interface for the single-line IDA was provided, but in this next phase, known as *IDA national service*, the national single-line IDA will always be connected via an IMUX (see Figure 15).

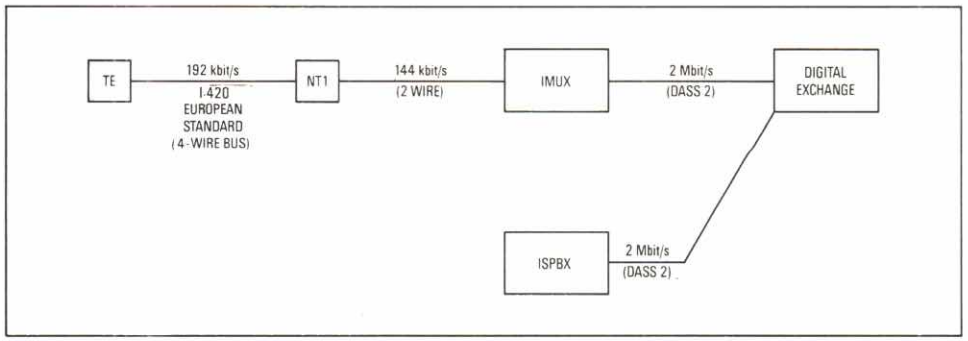


Figure 15
IDA national service

The IMUX will terminate the single-line IDA to the European standard for I-series interface, offering the single-line IDA customer access to two 64 kbit/s channels with the availability of a 16 kbit/s signalling D channel.

CONCLUSION

There is no doubt that ISDN is the beginning of a major revolution in public telecommunication networking capabilities.

Planning and development work is proceeding to provide more extensive coverage of ISDN within the UK. At the same time, British Telecom is ensuring that internationally agreed standards are implemented, to enable the network to integrate fully with other international networks as and when they become available.

GLOSSARY OF TERMS

Summary of Digital Terms

Digital — A DC signal that can take either one of two different values.

Binary — A numbering system using a base number or radix of 2. There are two digits, 1 and 0, in the binary system. In electrical terms, these may be related to ON and OFF.

Bit — Abbreviation for a binary digit, it is used to convey information in digital form, taking the value 1 or 0.

Byte — A number of bits, usually eight, which are handled as a unit. Within large computers, bytes are commonly referred to as *words*.

Baud — The modulation rate in data transmission. It is the rate at which a device such as a modem, changes its line signals.

Bit Rate — The number of bits transmitted per second. kbit/s refers to thousands of bits per second; Mbit/s refers to millions of bits per second.

Error Rate — A measure of the quality of a digital circuit or item of equipment. It is the number of erroneous bits or in a sample taken in a given period of time.

Summary of Datel Terms

Modem — An acronym for *mo*dulator/*demo*dulator. It is a device for converting binary information into a form suitable for sending over an analogue transmission line.

Half-Duplex — Data transmitted in both directions, but only in one direction at any one time.

Full-Duplex — The method of operation of a communication circuit in which each end can transmit and receive simultaneously.

Asynchronous — This is a term used to describe the mode of transmission. It is transmission in which each information character is preceded by a *start* signal which serves to prepare the receiving end for the reception of a character; the character is followed by a *stop* signal which brings the receiver to rest ready for the start of the next transmission. Asynchronous transmission may also use *start* and *stop* elements between blocks of characters rather than between individual characters.

Synchronous — This is a term used to describe the mode of transmission. Unlike asynchronous transmission, *start* and *stop* signals for each character or block of characters are not used; instead a clock is used to define each character or block of data. The transmitter and receiver are synchronised and the digits are counted to establish the start and finish of each character.

WAL2 — An encoding technique used in digital networks. It is used in both the network teminating units (NTUs) and network terminating equipments (NTEs) on British Telecom's IDA.

DCE — Data circuit-terminating equipment. Equipment to handle signal conversion and coding between data terminal equipment and a line. This equipment can often set up and terminate calls (for example, NTE4).

DTE

Data terminal equipment. Equipment that generates and/or receives data (for example, a terminal).

CCITT X-Series Recommendations

The CCITT X-series Recommendations concern the attachment of equipment to the digital network. Those used on British Telecom's pilot ISDN are:

X.21 — Interface between the data terminal equipment (DTE) and the data circuit-terminating equipment (DCE) for synchronous operation on public data networks.

X.21*bis* — Used on DTEs which are designed for interfacing to synchronous V-series modems.

CCITT V-Series Recommendations

The CCITT V-series Recommendations concern the attachment of digital data processing equipment to analogue networks. Those most likely to be met on IDA are:

V.24 — List of definitions for the interchange circuits (and their functions) between the data terminal equipment (DTE) and the data circuit-terminating equipment (DCE). It should be noted that the V.24 Recommendation does not include the electrical characteristics; they are contained in Recommendation V.28.

V.10/V.11 — The V28 Standard for electrical interface characteristics was based on the use of discrete components. Nowadays, with the use of integrated circuits, these standards are not compatible with more modern equipment. To overcome the problem, V.10 and V.11 standards were introduced.

V.10 relates to unbalanced double-current interface circuits.

V.11 relates to balanced double-current interface circuits.

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BACK NUMBERS

The price of back numbers of the *Journal* including the *Supplement* and postage and packaging is £2 (UK); £2.50 (overseas). The price to staff of British Telecom and the British Post Office is 90p per copy. (The *Supplement* is not sold separately.) Back issues can be ordered by using the form printed below.

Details of the question/answer material and educational papers published in back issues of the *Supplement* are shown below. For each subject, a list of back issues in which that subject appeared is given. Please note that each issue of the *Supplement* contains several subjects. Take care not to order a particular issue twice.

BTEC UNITS

(Question and answer material based on BTEC syllabi)

Digital Techniques II	Apr. 1983, Apr. 1984, Apr. 1985*, July 1986
Digital Techniques A III	Oct. 1983, July 1984, Oct. 1985, Oct. 1986
Electrical and Electronic Principles II	July 1983, Apr. 1984, Oct. 1985, Jan. 1987
Electrical and Electronic Principles III	Oct. 1983, Oct. 1984, Jan. 1986
Electrical Principles II	Jan. 1980, Jan. 1981, July 1982
Electronics II	Oct. 1980
Electronics III	July 1983, Apr. 1984, July 1985
Line and Customer Apparatus I	Jan. 1979, July 1981, Apr. 1982*, Apr. 1983, Apr. 1984, Oct. 1986
Lines II	Apr. 1981, Oct. 1982, Apr. 1984, Apr. 1985*, Apr. 1986, Apr. 1987
Lines III	July 1983, Apr. 1986
Mathematics I	Jan. 1979, Apr. 1980
Mathematics II	Apr. 1980, Apr. 1982*, July 1983, Apr. 1984, July 1985, Apr. 1986
Micro-Electronic Systems I	July 1983, Apr. 1984, Apr. 1985*
Micro-Electronic Systems II	Oct. 1983, July 1984, July 1985, July 1987
Physical Science I	Jan. 1979, Jan. 1980, July 1981
Radio II	Jan. 1983, Jan. 1984, Apr. 1985*
Radio III	July 1986
Telecommunications Systems I	July 1981, July 1982, July 1983, Jan. 1984, Jan. 1985*, July 1986
Telephone Switching Systems II	Jan. 1980, Oct. 1982, Oct. 1983, July 1984, Oct. 1985, Oct. 1986
Telephone Switching Systems III	Jan. 1983, Oct. 1984, Apr. 1986
Transmission Systems II	Jan. 1982*, Jan. 1983, Jan. 1984, Jan. 1985*, Jan. 1986, Jan. 1987
Transmission Systems III	Apr. 1983, Oct. 1985, Oct. 1986

CITY AND GUILDS OF LONDON INSTITUTE

(Answers to examination papers set by CGLI. Year of paper shown in brackets)

Circuit Theory T4	Apr. 1986 (1985), Apr. 1987 (1986)
Electrical Principles T3	Oct. 1986 (1985)
Electronics T3	Oct. 1986 (1985)
Electronics T4	Jan. 1987 (1985)
Microelectronic Systems T3 Option	Oct. 1986 (1985)
Microelectronic Systems T4 Option	July 1987 (1986)
Switching T4 Option	Jan. 1986 (1985), Jan. 1987 (1986)
Switching T5 Option	Apr. 1986 (1985), Apr. 1987 (1986)
Transmission T4 Option	July 1986 (1985), July 1987 (1986)
Transmission T5 Option	Apr. 1987 (1986)

EDUCATIONAL PAPERS PUBLISHED IN THE SUPPLEMENT

Field-Effect Transistors	Oct. 1982
Microcomputer Systems (Part 1)	Oct. 1984
Microcomputer Systems (Part 2)	Jan. 1985*
Digital Multiplexing	Apr. 1986
The Purposes of Teletraffic Engineering and its Application	Oct. 1987
A Guideline for Writing a System Requirements Specification for Computer Systems	Jan. 1988
An Introduction to 16 bit Microprocessors Part 1—8086/8088 Microprocessors	Apr. 1988
Integrated Services Digital Network	July 1988

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British Telecommunications Engineering

READERS' QUESTIONNAIRE 1988

Recent changes in the Business and Technician Education Council (BTEC) National Certificate engineering programme have prompted the Board of Editors to consider carefully the future role of the *Supplement*. For more than 50 years, the *Supplement* has been a popular source of reference for students studying for examinations, through its question/answer material based on City and Guilds of London Institute (CGLI) examinations, and TEC/BTEC and SCOTEC subjects. In recent issues, educational papers on a wide range of technical subjects have also been included. Not only has it been increasingly more difficult to secure question/answer material, but in the present climate of rapid technological change, the educational value of such material is becoming more suspect. In addition, the changes to the BTEC scheme, with new units and more emphasis on assessments in the form of practical assignments, suggest that the question/answer material is even less relevant and likely to be even more difficult to obtain.

The Board of Editors is now considering whether to cease, for the time being, the publication of the question/answer material and, instead, to devote the *Supplement* solely to educational papers, of which several representative papers have now been published. The purpose of this questionnaire is principally to seek readers' views on this major change of emphasis in the *Supplement*. A similar survey was published in the October 1982 issue of the *Supplement* and some 500 readers returned questionnaires indicating that they would like to see further educational papers published. However, at the time, it was not envisaged that educational papers would be the only type of material published in the *Supplement*.

The Board of Editors is also taking this opportunity to seek readers' general views on the main *Journal* itself. Finally, the Editors are always keen to enlist new authors for both the *Supplement* and *Journal*; if you feel that you could contribute an article or paper, please complete the final part of the questionnaire.

Please complete as much of the questionnaire as you wish, and return it to the editors as soon as possible. The questionnaire should be folded as indicated to show the FREEPOST address. No postage is required if posted in the UK.

PART A—PERSONAL DETAILS

---

1. Please give the following details (if you wish to reply anonymously, do so, but please give the other details):

Name .....

Organisation .....

Department .....

Rank/Position .....

If you are engaged in a course of study, please give details (for example, BTEC level.., SCOTVEC level.., main subjects.., etc:

.....

.....

Please indicate the category of your subscription to the *Journal*.

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☐ Employee of British Telecom or The Post Office, but not a Member of the IBTE or Associate Section

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☐ External customer

PART B—SUPPLEMENT

2. The introduction to this questionnaire describes the changes to the *Supplement* being considered by the Board of Editors; namely, to cease question/answer material and to concentrate on educational papers. However, the views of readers on the mix of material in the *Supplement* would be appreciated. What mix of material do you think should be included in the *Supplement*? (Place ticks against the categories.)

(*a*) ☐ Educational papers on a whole range of technical topics.

(*b*) ☐ Question/answer material based on BTEC/SCOTVEC subjects.

(*c*) ☐ Educational papers related specifically to BTEC/SCOTVEC subjects.

(*d*) ☐ Answers to CGLI examinations in the 271 Telecommunication Technicians Scheme (probably of most interest to overseas students).

(*e*) ☐ Other material. Please specify:

3. If you have ticked (*a*) educational papers, what subjects would you particularly like to see covered in forthcoming issues. Please also indicate, against each subject, the level of treatment that you would like to see.

4. If you have ticked (*b*) and/or (*c*) above, material related to BTEC/SCOTVEC subjects, what subjects/levels would you like to see covered?

PART C—JOURNAL

5. What is your general impression of the technical content of the main articles published in the *Journal* in relation to your needs?

☐ Far too technical ☐ About right ☐ Not technical enough

6. Indicate, on a scale of 5, your impression of whether the *Journal* is keeping you up-to-date with developments in telecommunications.

No 1 2 3 4 5 Yes

7. What is your general impression of the length of the main articles in the *Journal*?

☐ Too long ☐ About right ☐ Too short

8. Below are listed articles from the previous three issues of the *Journal*. For each article, state whether you have read the article, and indicate, on a scale of 5, your overall impression of the article. Your judgement might be based on whether you think that the article was too detailed, not detailed enough; enjoyable, dull; interesting, not interesting etc.

	Tick if you have read article(s)	Very Poor				Very Good
APRIL 1988 ISSUE:						
CCITT Signalling System No. 7 articles	☐	1	2	3	4	5
JANUARY 1988 ISSUE:						
Introduction of a Cyclic-Redundancy Check Procedure into the 2048 kbit/s Basic Frame Structure (p. 218)	☐	1	2	3	4	5
Optical Character Recognition System in Letter Mechanisation (p. 225)	☐	1	2	3	4	5
RASE—System for Recording and Scanning Alarms in the Digital Transmission Network (p. 232)	☐	1	2	3	4	5
An Introduction to the Digital Specific Equipment Assignment System and the Computerisation of Frame Management in the Digital Trunk Network (p. 238)	☐	1	2	3	4	5
Document Quality—Inspection (p. 250)	☐	1	2	3	4	5
LEKTOR Encyption System (p. 257)	☐	1	2	3	4	5
Intermail (p. 262)	☐	1	2	3	4	5
Telecommunications and International Finance (p. 265)	☐	1	2	3	4	5
Routining of Metering-over-Junction Circuits (p. 268)	☐	1	2	3	4	5
Transport and Telecommunications—Major Changes Under Way (p. 270)	☐	1	2	3	4	5
OCTOBER 1987 ISSUE:						
Growing Up in an Information Age (p. 154) Address to IBTE Martlesham Heath Centre	☐	1	2	3	4	5
Status Monitoring on Cable TV and Broadband Data Networks (p. 163)	☐	1	2	3	4	5
Events up to TELSTAR, 1962 (p. 170)	☐	1	2	3	4	5
Operation Skyward (p. 177)	☐	1	2	3	4	5
ELECTRA Mark 2—A Codemark Checking Machine (p. 181)	☐	1	2	3	4	5
Advances in High-Speed Phosphor Printing (p. 186)	☐	1	2	3	4	5
Connection-Control Protocols in a Fast Packet-Switched Multi-Service Network Based on ATD Techniques (p. 192)	☐	1	2	3	4	5
Telecommunications and Users (p. 199)	☐	1	2	3	4	5
Broadcasting: Challenge of the Future (p. 202) Frequency Spectrum Management	☐	1	2	3	4	5

9. In what ways do you think that the *Journal* could be improved?

10. What topics would you like to see covered in future *Journal* articles?

Would you like to see more articles on non-technical topics; for example, management, finance?

☐ YES ☐ NO

11. What other journals do you like/read in this field?

TUCK FLAP BETWEEN LEAVES OF FLAP A

PART D—CONTRIBUTIONS TO THE JOURNAL/SUPPLEMENT

12. If you feel that you might be able to contribute material for the *Journal* and/or *Supplement* (educational paper or otherwise), please give the following details and the Editors will contact you in the near future.

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Proposed Material:

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Please give further details about your proposed article:

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FLAP A